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Be well, sleep well: An examination of directionality between basic psychological needs and subjective sleep among emerging adults at university

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ABSTRACT

Objectives: The present study assessed bidirectional associations between basic psychological needs and several subjective sleep variables across 2 semesters.
Design: Participants completed an online survey twice (7 months apart) as part of a short-term longitudinal, correlational study.
Participants: Participants were 154 (67.8% female) emerging adults (mean age = 20.02 years, SD = 1.71) from a liberal arts university on the east coast.
Measurements: Survey assessed demographics, perceived fulfillment of basic psychological needs (autonomy, competence, and relatedness), and several sleep variables (week and weekend sleep duration, sleep disturbances, daytime dysfunction, and sleep quality; Pittsburgh Sleep Quality Index).
Results: Data were analyzed using an autoregressive cross-lagged model, which controlled for level of study, diagnosis of mental illness, self-esteem, social desirability, sleeping medication, chronotype, conscientiousness, and extraversion. Results indicated significant *unidirectional* associations: perceived fulfillment of basic psychological needs predicted longer week sleep duration ($\beta = .243$, $P = .008$) and better perceived sleep quality ($\beta = -.223$, $P = .008$) 1 semester later, and 1 significant *bidirectional* association, perceived fulfillment of basic psychological needs, predicted lower daytime dysfunction, and in turn, lower daytime dysfunction predicted higher perceived fulfillment of basic psychological needs 1 semester later.
Conclusions: Although many sleep interventions focus on environmental aspects of sleep, our findings highlight the importance of nurturing university students' psychological needs as a potential point of intervention for improving some sleep characteristics among emerging adults at university.

Sleep is an essential human behavior that is implicated in physical, psychological, and neurological processes that are critical for maintaining overall health and well-being.[1,2] Sleep is a multifaceted construct that encompasses a number of distinct, yet overlapping, parameters, including but not limited to the following: *sleep duration* (total sleep hours); *sleep disturbances* (extent to which aspects of one's sleeping environment affect the ability to initiate and/or maintain sleep); *daytime dysfunction* (perceived impairments in vitality and energy to perform daily activities due to dissatisfaction with sleep); *sleep quality* (one's subjective assessment of the overall restfulness of the sleep experience)[3]; bedtimes; wake times; and sleep-wake irregularity.[4] Sleep researchers also distinguish among sleep stages,[5] circadian phase preference, circadian timing, and phase angle.[6] Correlational and experimental evidence indicates a host of negative psychosocial correlates of poor sleep.[1,7–11] Notably, the unique context of university has spurred interest from sleep researchers eager to investigate factors that hinder optimal sleep behaviors,[12] particularly during key developmental age periods such as emerging adulthood.[13,14] This developmental age period (18-25 years old) is characterized as a period of instability and identity exploration.[15] For many emerging adults in the United States, attending university is a central feature of this age period.[16] Importantly, balancing social, academic, and personal demands of university is implicated in key developmental tasks of emerging adulthood.[17,18] Thus, it is essential to understand which factors motivate behavior toward the attainment of these goals.

An intriguing theory that seeks to explain underlying motives for goal-oriented behavior is the *basic psychological needs theory*

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(BPNT).[19] BPNT is 1 of 4 minitheories of the self-determination theory (SDT) proposed by Ryan and Deci.[19] SDT represents an empirically driven overarching model, which is used to evaluate human motivation, personality, and self-regulation in relation to well-being.[20] At its core, SDT prioritizes *type* or *form* of motivation over mere quantity—differentiating among autonomous motivation (ie, volition), controlled motivation (ie, externally driven), and amotivation (ie, the absence of motivation).[21] Another important element of SDT is its focus on eudaimonic vs hedonic well-being.[20] On one hand, hedonic approaches to well-being focus on examining feelings of pleasure or positive affect and the absence of negative affect, whereas eudaimonic approaches to well-being conceptualize well-being as self-realization and the fulfillment of one's full potential.[22]

According to the BPNT, there are 3 universal basic psychological needs (BPNs) that underlie human behavior: autonomy, competence, and relatedness. The need for *autonomy* is defined as volition; it refers to a desire to willfully endorse one's thoughts, feelings, and actions while recognizing that external influences are integral to one's sense of agency.[19,23] The need for *competence* refers to the experience of feeling effective in one's behavior; where one is able to freely express, develop, and effectively use personal skills in navigating challenges.[19] The need for *relatedness* includes having quality, reciprocal interpersonal relationships and experiencing a sense of connectedness to other people and communities.[19,23] The perceived fulfillment of these psychological needs is a critical determinant of eudaimonic well-being.[23] Furthermore, the perceived absence of these psychological needs is linked to poor psychological adjustment and ill-being.[19,23] Given the importance of sleep for overall health and well-being, as well as the link between BPN and mental health,[24] it is surprising that little research has examined the relationship between BPN and sleep. The primary purpose of the present study was to determine the direction of effects between BPN and sleep behaviors across 2 semesters among a sample of emerging adults at university.

Several characteristics of university life are intrinsically linked to sleep behaviors. Specifically, university students typically experience increased environmental noise because of shared living spaces,[25] lack direct parental supervision of sleep-wake timing,[26] and manage stressful academic demands.[27] University also allows for more flexibility in selecting class schedules,[4] as well as increased opportunities to socialize.[28] The negative implications of poor sleep are well documented: detriments to physical health,[9] increased risk-taking,[29] poor emotion regulation,[30] impaired cognitive performance,[7] poor quality social ties[79], and increased risk for mental illness.[31] Several studies also have examined various aspects of psychosocial adjustment (eg, academic performance, social ties, technology use, and substance use) as predictors of sleep[4,80,81]. Although there is empirical support for an improvement in sleep quality and duration from high school to university,[13] university students remain at risk for inadequate sleep duration, disturbed sleep, daytime sleepiness, and daytime dysfunction.[4,28]

In one study of more than 1000 emerging adults at a midwestern university in the United States, researchers found that although the average reported sleep duration met the minimum recommended sleep hours (ie, 7 hours) for this age period,[32] 25% of participants obtained less than 6.5 hours of sleep per night, and 20% reported pulling an all-nighter at least once in the past 30 days.[4] Becker and colleagues investigated prevalence rates of various sleep problems among a sample of more than 7600 university students across 6 universities in the United States and found that 35.7% of the sample reported obtaining less than 7 hours of sleep per night and 62% were classified as "poor sleepers" (based on the Pittsburgh Sleep Quality Index [PSQI] cutoff score of 5).[33] Notably, concerns about poor sleep quality and short sleep duration among university students is not limited to US samples. For example, in one Nigerian sample, 50% of these university students met the PSQI cutoff criteria for "poor sleep" and 45% reported obtaining between 6 and 7 hours of sleep per night.[34] Moreover, among students across 6 public and private universities in Lebanon, 52% reported getting less than 8 hours of sleep per night and 58.7% met the PSQI cutoff criteria for poor sleep.[35] Given these high prevalence rates of both short sleep duration and poor-quality sleep, research examining possible predictors and consequences of sleep characteristics among university students is warranted.

Similarly, there are several reasons why the examination of BPN (autonomy, competence, and relatedness) may be particularly warranted among university students, especially among those who choose to live away from home. University students typically experience increased opportunities to demonstrate autonomy with respect to their selection of and participation in classes,[36,37] decisions to commit to extracurricular activities and athletics,[38] making choices around diet and exercise,[39] and confronting institutional racism and sexism.[40] For students who choose to pursue university away from home, these decisions are made in the absence of direct, physical, parental contact. Moreover, students must demonstrate some level of competence to successfully navigate university. Assignments, tests, and examinations allow students to gauge their academic skills and capabilities but may result in significant stress and feelings of inadequacy if certain academic goals are not attained. Furthermore, there are critical interpersonal challenges that characterize the university experience, including establishing new platonic and romantic relationships [41,79], as well as navigating living conditions with roommates.[42] Taken together, these opportunities for autonomy, competence, and relatedness at university may pose significant challenges for some emerging adults, including social anxiety,[43] alcohol use/misuse,[44] general anxiety symptoms,[13] and depressive symptomatology.[45] Consequently, these psychosocial correlates may have negative implications for sleep.

Relative to the extensive amount of research on sleep in relation to negative psychological functioning, less is known about the *positive* psychosocial correlates of sleep.[46] In one cross-sectional study of middle-aged adults (58-72 years old), authors found a significant positive relationship between good sleep and eudaimonic well-being.[47] Few studies have specifically examined the association between basic psychological need satisfaction and sleep. In a recent study based on a Belgian sample of adults, Campbell and colleagues found that higher psychological need satisfaction (composite of autonomy, competence, and relatedness) was associated with lower daytime dysfunction, better perceived sleep quality, and longer sleep duration (however, neither autonomy, competence, nor relatedness was independently associated with sleep duration).[48] Although the authors proposed an effect *from* BPN *to* sleep, the cross-sectional design of the study failed to provide empirical support for the *directionality* of these associations.[48] In another cross-sectional study by the same authors, fulfillment of BPN was significantly associated with better perceived sleep quality but was unrelated to sleep duration among a sample of adults living with HIV.[24] In the only published (short-term) longitudinal study of BPN and sleep among university students to date, authors examined dynamic changes in the fulfillment of BPN in relation to sleep over the course of 3 months: before examinations (May), during examinations (June), and after examinations (July).[27] Results of latent change models indicated that changes in perceived need satisfaction and sleep were significantly correlated such that decreases in the perceived fulfillment of BPN from pre-examination to examination period were linked with significant increases in perceived poor sleep quality and daytime dysfunction, as well as decreases in sleep duration within that same time frame (ie, from pre-examination to examination period). Correspondingly, increases in perceived psychological need fulfillment from examination period to postexamination period were significantly correlated with decreases in perceived poor sleep quality and daytime dysfunction

(but were unrelated to changes in sleep duration).[27] Although this study provides valuable insight into the dynamic relationships between fulfillment of BPN and multiple dimensions of sleep among emerging adults at university, results are limited to the context of an examination period, and the authors did not specifically assess the temporal precedence (ie, directionality) between BPN and sleep behaviors.

The present study extends these findings by specifically assessing bidirectional associations between BPN and 5 sleep-related variables (week sleep duration, weekend sleep duration, sleep quality, sleep disturbances, and daytime dysfunction). Specifically, the study examined whether the perceived fulfillment of BPN predicts subsequent (residualized) changes in sleep behaviors or whether sleep behaviors predict subsequent (residualized) changes in BPN from one semester to the next, beyond the context of an examination period. We would like to highlight the fact that the use of the term *change* in relation to the proposed model and findings of the present study indicates *residualized* change (ie, the effect of a predictor at time 1 to an outcome at time 2, controlling for the effect of the outcome variable at time 1) and does *not* indicate causal associations, as these cannot be inferred given the correlational design of the present study.

Based on the rich body of research documenting the implications of poor sleep for health and well-being[7] as well as the assumption that the fulfillment of BPN drives goal-oriented behaviors,[49] we hypothesized that BPN would predict positive changes in sleep behaviors (specifically longer sleep duration, lower daytime dysfunction, less sleep disturbances, and better perceived sleep quality) 1 semester later. We also predicted that better sleep behaviors (specifically longer sleep duration, lower daytime dysfunction, less sleep disturbances, and better perceived sleep quality) would predict increases in BPN over time. Furthermore, based on the available research, we hypothesized that BPN would be more strongly linked with sleep quality, sleep disturbances, and daytime dysfunction relative to sleep duration.

Possible confounding variables

To test the proposed model, it was important to control for several factors that have been linked to sleep and/or BPN. Specifically, we controlled for level of study, diagnosis of mental illness, self-esteem, social desirability, chronotype, use of sleeping medication, and personality (ie, conscientiousness and extraversion). Past research has shown that university freshmen report longer sleep duration and have more irregular week-to-weekend bedtime and wake time patterns relative to upper-division students.[4,50] Diagnosis of mental illness was included as a covariate to account for the well-established link between various indices of mental health (eg, depression, anxiety, perceived stress) and sleep problems, both at the clinical and subclinical levels.[25,51,52] Past research also has linked mental illness with perceived fulfillment of BPN. Specifically, in one study of individuals with first-episode psychosis, higher perceived fulfillment of BPN was significantly linked to less severe symptomatology.[53] Furthermore, individuals with psychosis generally tend to report lower perceived fulfillment of autonomy, competence, and relatedness relative to individuals without psychosis.[54] Moreover, having a mental illness diagnosis has been linked to lower basic need satisfaction among university students.[55]

In one study of university students in Turkey, authors confirmed a significant positive association between perceived satisfaction of BPN (specifically, autonomy and competence) and self-esteem.[56] Although the authors conducted a cross-sectional study, the interpretation of their findings assumed directionality *from* BPN *to* self-esteem.[56] However, Ryan and Brown suggest that the nature of the association between these 2 constructs may be bidirectional. The authors noted that a preoccupation with contingent self-esteem may compromise one's perceptions of need fulfillment or satisfaction (specifically, the authors state that low self-esteem may compromise volition), and in turn, perceived unfulfilled BPN may lead to low self-esteem.[57] Importantly, the authors also note that "the search for [self-] esteem blocks rather than enhances growth."[57] Thus, given both the theoretical and empirical support for a link between self-esteem and BPN, we thought it worthwhile to account for the possible *dynamic* association between these 2 constructs in our model. Moreover, given the study's procedure (ie, online survey) and the personal nature of some of the constructs, we included a measure of social desirability to account for possible demand characteristics in participants' responses.

Numerous studies have demonstrated a significant effect of chronotype on sleep-wake patterns and sleep quality. Consistently, evening types typically report later bedtimes and wake times, more sleep problems, more irregular sleep-wake timing, and higher daytime dysfunction relative to morning types.[37,58] We also accounted for the fact that the use of sleeping medication may influence individuals' sleep characteristics. One would assume that the use of sleeping medication would be prompted by poor sleep characteristics (eg, difficulty initiating or maintaining sleep, longer sleep onset latency)[59]; however, consequently, those who use sleeping medication—if effective—may experience improved sleep.

The final construct that we controlled for was personality. Empirical evidence, based on longitudinal data among US and Japanese older adults, suggests that poorer sleep at baseline predicted greater declines in conscientiousness and extraversion over time, whereas higher extraversion at baseline predicted improved sleep quality over time.[60] Among a sample of university students from Turkey, results indicated significant concurrent associations between sleep and personality such that higher perceived sleep problems were associated with both lower extraversion and conscientiousness.[61] In terms of the relationship between BPN and personality, cross-cultural empirical evidence supports the notion that the perceived fulfillment of BPN provides a nurturing context within which individuals are able to reveal their authentic personalities.[19] For example, in one study, researchers examined the association between autonomous support and discrepancies in *ideal* vs *actual* personality traits.[62,63]

Participants and methods

Participants and procedures

Participants were 154 emerging adults (67.8% female) at a small, liberal arts university (mean age = 20.02 years old, SD = 1.71) in the United States who participated in a longitudinal study on sleep, stress, and psychosocial adjustment at university. Recruitment procedures included in-person contact (gym, cafeteria), social media posts, fliers, and class announcements. Notably, we specifically aimed to have equal representation of student athletes and nonathletes in our sample for the following reasons: (1) in addition to having more structured schedules, some athletes typically train in the early morning, which may directly disrupt wake times; (2) athletes often travel for games when in season, which means that they may experience more frequent changes in their sleep environments (eg, sleeping in a hotel or on a bus when commuting for games) relative to nonathletes; and (3) given the importance of sleep for optimal physical performance, athletes may differ from nonathletes in their awareness of, and advice on, maintaining healthy sleep hygiene routines because coaches may help to facilitate that knowledge.

Of the 249 prospective participants who signed up to participate during recruitment, 187 (75%) completed the online survey at time 1. The sample comprised 57 (30.5%) freshmen, 66 (35.3%) sophomores, 31 (16.6%) juniors, 30 (16%) seniors, and 3 (1.6%) graduate

students. Participants completed the survey at their convenience using their personal computers or cell phones between February and March of 2017 (before their scheduled spring break). Questionnaires assessed a host of psychosocial indices, including physical activity, interpersonal relationships, and psychological well-being.

One semester later (fall 2017), the same participants were invited (via e-mail) to complete the same survey (time 2). However, given that the present study examined associations between BPN and sleep *at* university, we excluded participants who were no longer students at the university at time 2 (n = 33). Of the eligible 154 participants (n = 77, 50% student-athletes), 121 (79%) agreed to participate at time 2 and completed the same survey from the initial assessment. At time 2, participants completed the online survey between October and November of 2017.

In terms of family income, 40% of participants reported an annual family income of more than $100,000, 30% indicated "I don't know," and the remaining 30% reported an annual family income between $0 and $100,000. Lastly, 14.3% (n = 22) of participants indicated that they had been professionally diagnosed with a mental illness. At time 1, participants were compensated $10.00 or received 1-hour research participation credit as part of their introductory psychology course. At time 2, all participants were compensated $10.00 for completing the survey. All participants provided active consent prior to participation. The study was reviewed and approved by the Institutional Review Board at Wesleyan University.

Measures

References, example items, scale anchors, and item reliability scores (Cronbach α) for all study measures are presented in Table 1.

Basic Psychological Needs

Perceived fulfillment of BPN was assessed using 11 items from the Basic Psychological Needs–Work Domain Questionnaire.[64] Items were adapted for an academic setting by replacing references to "work" or "job" with "school" or "class". The 11 items were averaged across the 3 subscales (Cronbach $\alpha = .765$): ***autonomy*** (eg, *"There is not much opportunity for me to decide for myself how to go about my school work"*), ***competence*** (eg, *"I do not feel very competent when I am at school"*), and ***relatedness*** (eg, *"The people I attend classes with do not seem to like me much"*). The composite score was created by averaging scores across the 11 items. Scores were coded such that higher scores indicate greater perceived fulfillment of BPN.

Sleep

We assessed 5 different sleep variables. Week and weekend sleep duration were calculated from participant-reported bedtimes

Table 1
References, example items, scale anchors, and reliability for all study measures

Variable	Reference	No. of items	Example item	Scale anchor	Cronbach α
Age		1	"What is your date of birth?"	N/A	N/A
Gender		1	"Gender"	0 = female, 1 = male	N/A
Family income		1	"What is the TOTAL income in the last calendar year, including parents' salaries and all other sources of income for all household members?"	1 = $0-$25,000, 6 = over $150,000 to 7 = I don't know	N/A
Level of study		1	"What is your level of study?"	1 = freshman, 2 = sophomore, 3 = junior, 4 = senior, 5 = graduate student	N/A
Diagnosis of a mental disorder		1	"Have you ever been diagnosed by a physician or other health professional for depression, anxiety, or any other mental illness?"	0 = no, 1 = yes	N/A
Self-esteem	Rosenberg Self-Esteem Scale (Rosenberg, 1979)[82]	6	"I feel that I am a person of worth, at least equal to others"	1 = strongly agree to 5 = strongly disagree	0.873
BPN	Basic Psychological Needs Scale (Deci et al., 2001)[64]	11	"There is not much opportunity for me to decide for myself how to go about my school work" (A) "I do not feel very competent when I am at school" (C) "The people I attend classes with do not seem to like me very much" (R)	1 = not at all true to 7 = very true	0.765
Sleep duration		2	"During the WEEK (WEEKEND), what time do you normally fall asleep?" and "During the WEEK (WEEKEND), what time do you normally get out of bed in the morning (ie, your final wake time)?"	N/A	
Sleep disturbances	PSQI (Buysse et al, 1988)[3]	9	"Woken up by someone else's cough or snore"	0 = not at all to 3 = 3 or more times a week	0.663
Daytime dysfunction	PSQI (Buysse et al, 1988)[3]	2	"Since the start of this semester, how often have you had trouble staying awake while driving, eating meals, studying, engaging in social activity?"	0 = not at all to 3 = 3 or more times a week	N/A
Sleep quality	PSQI (Buysse et al, 1988)[3]	1	"Since the start of the semester, how would you rate your sleep quality overall?"	0 = very good to 3 = very bad	N/A
Sleeping medication	PSQI (Buysse et al, 1989)[3]	1	"During the past month, how often have you taken medicine (prescribed or "over the counter") to help you sleep?"	0 = not at all during the past month to 3 = 3 or more times a week	N/A
Chronotype	MEQ (Adan & Almirall, 1990)[67]	19	"What time would you wake up if you were absolutely free to plan your day and didn't have any academic or social commitments?"	1 = not at all to 4 = a lot	0.831
Social desirability	Social Desirability Scale (Reynolds, 1982)[66]	5	"I am always courteous, even to people who are disagreeable"	1 = definitely true to 5 = definitely false	0.672
Personality	BFI (Pervin & John, 1999)[68]				
Conscientiousness		9	"I see myself as someone who does things efficiently"	1 = strongly disagree to 5 = strongly agree	0.789
Extraversion		8	"I see myself as someone who is full of energy"	1 = strongly disagree to 5 = strongly agree	0.868

("During the WEEK (WEEKEND), what time do you normally fall asleep?") and wake times ("During the WEEK (WEEKEND), what time do you normally get out of bed in the morning (ie, your final wake time)?"). ***Sleep disturbances*** (eg, "cough or snore loudly," "wake up in the middle of the night or early morning"), **daytime dysfunction** (eg, "Since the start of this semester, how much of a problem has it been for you to keep up enough enthusiasm to get things done?"), and **perceived sleep quality** (eg, "Since the start of this semester, how would you rate your overall sleep quality?") were operationalized using items from the PSQI.[3]

Covariates

Level of study, diagnosis of mental illness, self-esteem, sleeping medication,[65] social desirability,[66] chronotype,[67] conscientiousness,[68] and extraversion[68] were assessed as covariates (see Table 1 for detailed information on these measures).

Plan of analysis

Missing data

Survey completion rates were high at time 1; average missing data across the study measures in the present study were 2.7% (range 0%-5.8%). At time 2, however, there was significant attrition; average missing data on study variables at time 2 were 40.8% (range 37.7%-45.5%). The low response rate was likely due to a combination of factors, including the *timing* of the second assessment (near midsemester examinations) and participant fatigue (completion of the survey was only 1 component of a larger study in which participants committed to daily assessments across a 7-day period). Missing values analysis was conducted to determine the pattern of missing data. Analyses indicated that noncompleters at time 2 did not differ from completers on 10 of the 14 variables included in the study: BPN, week sleep duration, weekend sleep duration, sleep quality, sleep disturbances, daytime dysfunction, sleeping medication, level of study, diagnosis of mental illness, and social desirability. However, individuals with missing data on chronotype at time 2 had higher social desirability ($P = .022$) and lower sleep duration during the week ($P = .042$) at baseline. Individuals with missing data on self-esteem at time 2 had higher extraversion scores at baseline ($P = .041$); those with missing data on conscientiousness at time 2 had higher social desirability ($P = .049$) and extraversion ($P = .026$) scores at baseline. Lastly, individuals with missing data on extraversion at Time 2 had higher extraversion scores at baseline ($P = .026$)—a finding that indicates significant bias in the pattern of missingness on this variable. Findings, therefore, should be interpreted against the backdrop of this critical limitation of the present study. Missing data were imputed using full information maximum likelihood.[69]

Primary analyses

Data were analyzed in Amos (version 25). An autoregressive cross-lagged path model was used to assess bidirectional associations between a composite measure of BPN (averaged across items from the autonomy, competence, and relatedness subscales) and 5 sleep variables: week sleep duration, weekend sleep duration, sleep disturbances, daytime dysfunction, and perceived sleep quality. Autoregressive paths were specified for each of these 6 variables from time 1 to time 2. Additionally, cross-lagged paths were specified among all 6 variables (ie, paths were specified from each of the sleep variables at time 1 to the BPN composite at time 2; additional paths were specified from the BPN composite at time 1 to each of the sleep variables at time 2).

Autoregressive paths were specified for each of the following covariates: self-esteem, social desirability, chronotype, sleeping medication, conscientiousness, and extraversion. The model also accounted for the possible bidirectional association between self-esteem and BPN by including cross-lagged paths between these 2 variables. Furthermore, given the role of chronotype on sleep, we specified unidirectional paths from chronotype at time 1 to each of the 5 sleep variables at time 2. Results of a MANOVA indicated that student-athletes and nonathletes did not differ on any of the study variables, $\lambda = 0.870$, $F_{11,125} = 1.703$, $P = .080$; thus, athlete status was dropped as a covariate.

Covariances were specified among all variables at time 1 (level of study, mental illness diagnosis, self-esteem, social desirability, chronotype, sleeping medication, conscientiousness, extraversion, week sleep duration, weekend sleep duration, sleep quality, sleep disturbances, daytime dysfunction, and BPN). Covariances also were specified between each pair of error terms for all endogenous variables at time 2. All continuous variables were standardized.

Model fit was assessed by examining χ^2 test of independence, comparative fit index, and the root mean square error of approximation. Model fit was acceptable: $\chi^2\ (140) = 237.396$, $P < .001$; comparative fit index = .901, root mean square error of approximation = .067, 90% confidence interval = .052-.082.[70]

Secondary analyses

As part of our secondary analyses, we ran 3 separate models assessing the 3 subcomponents of BPN (autonomy, competence, and relatedness) as independent variables within the autoregressive cross-lagged model described above. Results of these secondary analyses are available in an online supplement.

Results

Descriptive statistics are presented in Table 2. Bivariate correlations among all study variables at time 1 and time 2 are presented in Tables 3 and 4, respectively. Bivariate correlations indicated that at both assessments, higher perceived fulfillment of BPN was associated with better sleep quality; higher self-esteem, conscientiousness, and extraversion, and lower social desirability and daytime dysfunction. Furthermore, at baseline (but not at time 2), higher

Table 2
Means, standard deviations, ranges, and frequencies for key study variables

Variables	Mean (SD) or % where applicable	Range
Age	20.02 y old (1.71)	18.33-37.5 y old
Gender	Female (67.8%), Male (32.2%)	N/A
Level of study	Freshman (37%), sophomore (42.9%), junior (20.1%)	N/A
Mental illness diagnosis	No diagnosis (84.8%), Diagnosed (15.2%)	N/A
Family income		
$0-$25,000	6.5%	
$25,001-$50,000	8.4%	
$50,001-$80,000	6.5%	
$80,001-$100,000	10.4%	
$100,001-$150,000	13.0%	
>$150,000	26.6%	
Self-esteem	24.19 (4.04)	10.00-30.00
Sleeping medication	0.44 (0.82)	0.00-3.00
Social desirability	2.44 (0.66)	1.00-5.00
Chronotype	48.88 (8.11)	27.00-72.00
Extraversion	26.52 (6026)	8.00-40.00
Conscientiousness	33.03 (5.17)	9.00-45.00
Sleep duration (week)	7 h, 48 min (1.13 h)	4.00-10.00
Sleep duration (weekend)	8 h, 23 min (1.19 h)	5.00-12.50
Sleep disturbances	1.16 (0.45)	0.00-3.00
Daytime dysfunction	1.44 (0.77)	0.00-3.00
Sleep quality	1.22 (0.59)	0.00-3.00
BPN	5.00 (0.80)	1. 00-7.00

N = 154.

Table 3
Bivariate correlations among all study variables at time 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. BPN_1	1														
2. $SD\text{-}WEEK_1$	.17*	1													
3. $SD\text{-}WEEKEND_1$	.04	.03	1												
4. $SLEEP\ QUAL_1$	−.26**	−.37***	.10	1											
5. $SLEEP\ DIST_1$	−.22**	−.04	−.03	.13	1										
6. $DAY\text{-}DYS_1$	−.24**	−.15	.03	.35***	.18*	1									
7. $CHRONOTYPE_1$	.07	.24**	−.29***	−.32***	.10	−.23**	1								
8. $SLEEP\text{-}MED_1$	−.20*	−.11	.03	.25**	.21*	.06	−.05	1							
9. $SELF\text{-}EST_1$	.52***	.04	.07	−.27**	−.12	−.24**	.08	−.15	1						
10. $M\text{-}DIAGNOS_1$	−.20*	−.15	−.01	.19*	.25**	.26**	.00	.34***	−.32***	1					
11. $CONSCIEN_1$	.35***	.07	−.12	−.26**	.02	−.27**	.37***	−.16*	.37***	−.13	1				
12. $EXTRAV_1$	.34***	.02	−.15	−.16	−.02	−.01	.05	.07	.34***	.02	.06	1			
13. $LEVEL_1$	.07	.09	−.17*	−.14	−.05	.03	.08	−.00	−.00	.11	.09	.05	1		
14. $SOC\text{-}DES_1$	−.23**	−.09	−.09	.14	.03	.19*	−.06	.10	−.30***	−.01	−.34***	.06	.02	1	

N = 154; *$P < .05$, **$P < .01$, ***$P < .001$. SD-WEEK = sleep duration during the week, SD-WEEKEND = sleep duration during the weekend, SLEEP QUAL = poor sleep quality, SLEEP DIST = sleep disturbances, DAY-DYS = daytime dysfunction, CHRONOTYPE = morningness preference, SLEEP-MED = sleep medicine, SELF-EST = self-esteem, M-DIAGNOS = mental illness diagnosis, CONSCIEN = conscientiousness, EXTRAV = extraversion, LEVEL = level of study, and SOC-DES = social desirability. Subscript 1 indicates time 1 (spring semester, 2017).

perceived fulfillment of BPN was significantly correlated with longer week sleep duration, fewer sleep disturbances, and lower risk of having a mental illness. At baseline, having a higher morningness preference was significantly linked to longer week sleep duration, shorter weekend sleep duration, better sleep quality, and lower daytime dysfunction.

Autoregressive paths

All autoregressive paths were positive and significant (Table 5), indicating that variables were generally stable across the 2 semesters. Standardized regression weights for the autoregressive paths ranged from $\beta = .273$ ($P < .001$) for sleep duration during the weekend to $\beta = .825$ for extraversion ($P < .001$), indicating some variability in the level of stability across variables.

Cross-lagged paths: associations between BPN and sleep

All significant cross-lagged paths are presented in Figure 1. There were 2 significant *unidirectional paths* such that BPN at time 1 predicted longer sleep duration during the week ($\beta = .243$, $P = .008$) and better perceived sleep quality ($\beta = -.233$, $P = .008$) at time 2.

Additionally, there was one significant *bidirectional* association such that BPN at time 1 predicted lower daytime dysfunction at time 2 ($\beta = -.164$, $P = .029$), and in turn, lower daytime dysfunction at time 1 predicted higher perceived fulfillment of BPN at time 2 ($\beta = -.180$, $P = .015$).

Discussion

The purpose of the present study was to examine bidirectional associations between the perceived fulfillment of BPN and 5 sleep variables (week sleep duration, weekend sleep duration, sleep disturbances, daytime dysfunction, and sleep quality) among emerging adults at university. Results indicated 2 significant unidirectional associations such that the perceived fulfillment of BPN predicted longer week sleep duration and better sleep quality 1 semester later. Furthermore, we found evidence for one significant bidirectional association such that higher perceived fulfillment of BPN at baseline predicted lower daytime dysfunction at the second assessment, and in turn, lower daytime dysfunction at baseline predicted higher perceived fulfillment of BPN 7 months later.

Our findings show that BPN *precede* changes in 2 sleep variables (week sleep duration and perceived sleep quality) among our sample of university students. The perceived fulfillment of BPN (autonomy, competence, and relatedness) may improve sleep duration and quality through increased positive affect and eudaimonic well-being. Positive affect may promote good sleep both directly as well as indirectly through stress-buffering mechanisms (reduced negative affect and improved emotion regulation).[46] Steptoe and colleagues found that both positive affect (feeling happy, excited, or content)

Table 4
Bivariate correlations among all study variables at time 2

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. BPN_2	1														
2. $SD\text{-}WEEK_2$	.19	1													
3. $SD\text{-}WEEKEND_2$	−.13	.27**	1												
4. $SLEEP\ QUAL_2$	−.26*	−.44***	−.01	1											
5. $SLEEP\ DIST_2$	−.13	.06	.045	.29**	1										
6. $DAY\text{-}DYS_2$	−.42***	−.11	.27**	.26*	.18	1									
7. $CHRONOTYPE_2$	−.04	.10	−.30**	−.08	−.07	−.28**	1								
8. $SLEEP\text{-}MED_2$	−.10	.06	.23*	.12	.27**	.15	−.00	1							
9. $SELF\text{-}EST_2$	.49***	.10	.18	−.20	−.02	−.32**	−.09	−.07	1						
10. $M\text{-}DIAGNOS_1$	−.12	.24*	.09	−.17	.00	.13	.06	.09	−.14	1					
11. $CONSCIEN_2$	.46***	.25*	−.20	−.09	.00	−.38***	.18	.04	.49***	−.13	1				
12. $EXTRAV_2$	.51***	.08	−.16	−.09	−.01	−.08	−.12	.08	.28*	.02	.08	1			
13. $LEVEL_1$	.17	.12	−.10	−.01	.09	−.23*	.14	−.02	.08	.11	.08	.08	1		
14. $SOC\text{-}DES_2$	−.23*	.03	.04	−.01	−.15	.04	−.04	.07	−.28	−.01	−.17	−.07	.02	1	

N = 154; *$P < .05$, **$P < .01$, ***$P < .001$. Subscripts 1 and 2 indicate time 1 (spring semester, 2017) and time 2 (fall semester, 2017), respectively.

Table 5
Results of autoregressive and cross-lagged paths between BPN and sleep characteristics

Path	B	SE	β	P
BPN_1 ➔ BPN_2	.503	.082	.515	<**.001**
Sleep duration $(week)_1$ ➔ sleep duration $(week)_2$	.327	.085	.324	<**.001**
Sleep duration $(weekend)_1$ ➔ sleep duration $(weekend)_2$	.275	.083	.273	<**.001**
Sleep $quality_1$ ➔ sleep $quality_2$	.364	.086	.350	<**.001**
Sleep $disturbances_1$ ➔ sleep $disturbances_2$	.505	.085	.507	<**.001**
Daytime $dysfunction_1$ ➔ daytime $dysfunction_2$	.510	.075	.510	<**.001**
$Chronotype_1$ ➔ $chronotype_2$	.871	.060	.824	<**.001**
Sleeping $medication_1$ ➔ sleeping $medication_2$	.547	.081	.536	<**.001**
Self-$esteem_1$ ➔ Self-$esteem_2$	.633	.076	.650	<**.001**
Social $desirability_1$ ➔ social $desirability_2$	.519	.079	.522	<**.001**
$Conscientiousness_1$ ➔ $conscientiousness_2$	.739	.063	.752	<**.001**
$Extraversion_1$ ➔ $extraversion_2$	.807	.050	.825	<**.001**
BPN_1 ➔ sleep duration $(week)_2$	.245	.093	.243	**.008**
BPN_1 ➔ sleep duration $(weekend)_2$	.021	.088	.020	.816
BPN_1 ➔ sleep $quality_2$	−.241	.091	−.233	**.008**
BPN_1 ➔ sleep $disturbances_2$	.011	.087	.011	.902
BPN_1 ➔ daytime $dysfunction_2$	−.164	.075	−.164	**.029**
BPN_1 ➔ self-$esteem_2$	.118	.079	.121	.132
Sleep duration $(week)_1$ ➔ BPN_2	−.040	.072	−.041	.576
Sleep duration $(weekend)_1$ ➔ BPN_2	.020	.068	.020	.768
Sleep $quality_1$ ➔ BPN_2	.088	.078	.089	.263
Sleep $disturbances_1$ ➔ BPN_2	.052	.069	.053	.451
Daytime $dysfunction_1$ ➔ BPN_2	−.177	.072	−.180	**.015**
Self-$esteem_1$ ➔ BPN_2	.143	.079	.147	.071
$Chronotype_1$ ➔ sleep duration $(week)_2$	.040	.094	.039	.673
$Chronotype_1$ ➔ sleep duration $(weekend)_2$	−.232	.090	−.232	**.010**
$Chronotype_1$ ➔ sleep $quality_2$	−.152	.092	−.147	.097
$Chronotype_1$ ➔ sleep $disturbances_2$	−.209	.086	−.210	**.015**
$Chronotype_1$ ➔ daytime $dysfunction_2$	−.225	.076	−.226	**.003**

and eudaimonic well-being (needs satisfaction within the domains of control, autonomy, pleasure, and self-realization) were significant concurrent predictors of good sleep quality among a sample of middle-aged adults. Furthermore, among a sample of working adults, higher perceived autonomy and relatedness were significantly positively linked with vitality and positive affect, and negatively linked with negative affect.[71] Unmet psychological needs may result in feelings of inadequacy, frustration, and anxiety,[23] which, in turn, may prompt negative presleep arousal (eg, worries), subsequently impeding sleep.[72] Notably, in one study of university undergraduates, increased stress levels from baseline (pre-examination) to examination period significantly mediated the significant correlation between changes in BPN and poor sleep quality (but not sleep quantity).[27]

Additionally, the fulfillment of BPN may relate to subsequent improvements in subjective sleep through increased intrinsic motivation toward goal-directed behaviors.[23] Emerging adults—aware of the importance of good sleep for cognitive, physical, and psychological functioning—may be more inclined to adopt good sleep hygiene,[25] possibly facilitating both longer and better sleep. In support of this reasoning, past studies have shown a positive relationship between conscientiousness and sleep quality.[60] Time management may be an important consideration in one's ability to fulfill their BPN. Effective time management allows students to have a sense of autonomy by having control over their class schedules, demonstrate competence by completing work efficiently, and obtain a feeling of belongingness by making time to socialize with friends. Consequently, those who effectively juggle the demands of university and achieve their BPNs may subsequently be more vigilant about the importance of their sleep-wake timing, particularly during the week.

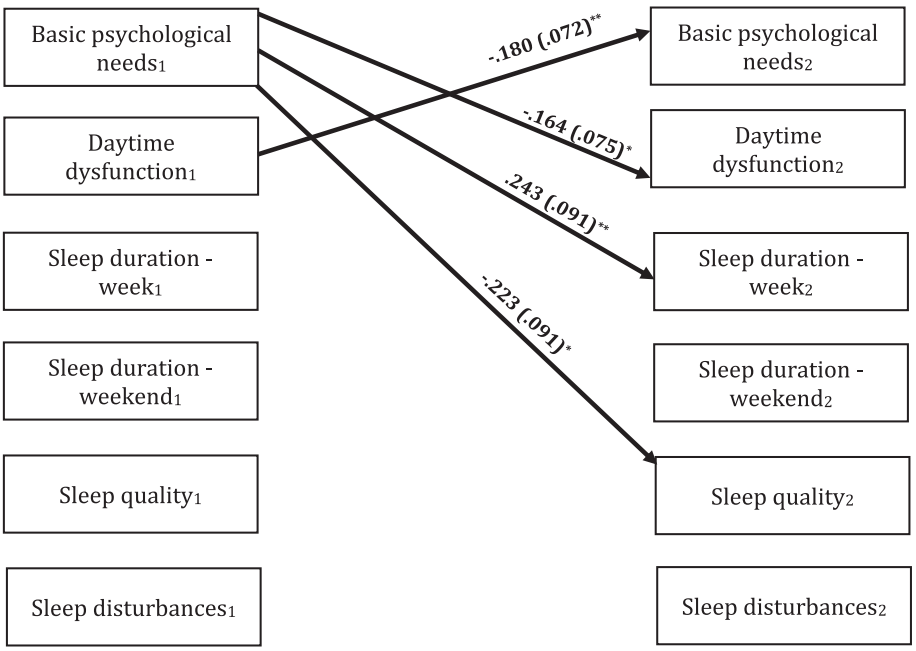

Fig. 1. Significant cross-lagged paths between BPN and sleep[1]. *Note: Subscripts 1 and 2 indicate time 1 and time 2, respectively. Not shown are significant autoregressive paths for all variables. Model controlled for level of study, diagnosis of mental illness, self-esteem, social desirability, use of sleeping medication, chronotype, conscientiousness, and extraversion. [1]Results of 3 separate models examining the associations between the each of the three individual components of the BPN construct indicate that the fulfillment of BPN within the **autonomy** domain predicted longer week sleep duration ($B = .187$, SE = .094, $\beta = .186$, $P = .046$) and better sleep quality ($B = -.229$, SE = .091, $\beta = -.224$, $P = .012$), with a trend effect for lower daytime dysfunction ($B = -.144$, SE = .075, $\beta = -.144$, $P = .055$); the path from sleep disturbances to BPN within (autonomy) was trending, ($B = -.142$, SE = .076, $\beta = -.145$, $P = .064$). The fulfillment of BPN within the **competence** domain predicted longer week sleep duration ($B = .240$, SE = .094, $\beta = .238$, $P = .010$) and lower daytime dysfunction ($B = -.210$, SE = .075, $\beta = -.208$, $P = .005$); the path from BPN (competence) to sleep quality was trending, ($B = -.173$, SE = .092, $\beta = -.167$, $P = .060$). The fulfillment of BPN within the **relatedness** domain did not predict any sleep outcomes, but there was a trend for BPN (relatedness) to sleep quality ($B = -.159$, SE = .091, $\beta = -.154$, $P = .082$); the path from daytime dysfunction to BPN (relatedness) was trending ($B = -.139$, SE = .077, $\beta = -.140$, $P = .071$).

Notably, past research has consistently demonstrated a link between the fulfillment of BPN and various indices of well-being (eg, vitality, positive affect, and effective emotion regulation).[23,64] Our findings make a significant contribution to the field by demonstrating some level of directionality between BPN and a critical human behavior: sleep (within the context of an autoregressive cross-lagged model). It is critical for future research to assess the possible mediating role of subjective sleep as a key mechanism that explains the relationship between BPN and well-being.

Our findings demonstrated a significant *bidirectional* association between perceived fulfillment of BPN and daytime dysfunction. This finding fits with past research that has reported a significant association between these 2 constructs.[27,71] In one study of university students, Campbell and colleagues showed that the association between perceived decreases in BPN satisfaction and lower daytime dysfunction was mediated by changes in perceived stress.[27] Our findings indicate a significant mutual relationship between students' perception of basic psychological need satisfaction and their ability to effectively function during the day. In the present study, daytime dysfunction was operationalized as a composite of perceived enthusiasm and sleepiness. Proponents of the self-determination theory highlight the importance of BPN for providing key *nutrients* that facilitate both somatic and psychological outcomes.[19,71,73] Our findings suggest that one's perceived level of enthusiasm and vitality may, in fact, provide a fertile environment within which BPN can be facilitated. More research is needed to validate this dynamic relationship among more diverse groups of university students. Future research also needs to identify the specific types of academic (eg, classes) and nonacademic (eg, extracurricular activities) experiences that boost students' perceived enthusiasm. Moreover, future research is needed to determine the specific aspects of daytime functioning (ie, cognitive, physical, emotional) that may be most influenced by feelings of autonomy, competence, and relatedness.

The fulfillment of BPN was not associated with changes in weekend sleep duration and sleep disturbances. One reason for the null association between BPN and *weekend* sleep duration may be related to the function that weekend sleep typically serves within university populations (ie, "catch up" sleep).[4] Both university students who perceive their BPN as fulfilled and those who perceive their BPN as unmet may have similar sleep duration on the weekends, but for different reasons. For example, university students who perceive their BPN as unmet may sleep longer on the weekend as a way of coping with psychological distress that may accompany unmet psychological needs,[74] whereas university students who perceive their BPN as fulfilled may sleep longer as a way of prioritizing sleep given that week sleep is typically shortened due to academic schedules.[4] Furthermore, our findings indicated a null effect between BPN and sleep disturbances. One reason for a lack of association between these 2 constructs may be related to the specific items that were used to assess sleep disturbances. Some items asked about environmental factors that affect sleep, for which individuals may have little or no control over, regardless of their perception of their BPN (eg, "feeling too hot" or "feeling too cold"). Thus, individuals may experience disturbed sleep based on these factors, regardless of their perceived psychological needs.

With the exception of daytime dysfunction, none of the sleep-related variables at baseline predicted BPN across the 2 semesters. One reason for this finding could be that individuals who experience good sleep may subsequently perceive high fulfillment of their BPN because of the cognitive and psychological benefits of good sleep for executing goal-directed behaviors.[23,49] At the same time, individuals with poor sleep may subsequently perceive high fulfillment of their BPN because of the decision to compromise sleep to fulfill their BPN.

Lastly, an important sleep-related covariate, chronotype, showed significant associations with sleep outcomes. Specifically, having a morningness preference at baseline predicted shorter weekend sleep duration, fewer sleep disturbances, and lower daytime dysfunction 7 months later. These findings add to several past studies that have consistently documented differences in sleep-wake behaviors between morning types and evening types.[37,75] These differences may be explained due to the underlying physiological differences in circadian rhythms (eg, dim light melatonin onset, cortisol, and body temperature).[76] Additionally, evening types and morning types may have different sleep experiences because of environmental factors, such as alcohol use, caffeine,[37] and sleep hygiene practices.[37,81]

Limitations and future directions

The present study used an autoregressive cross-lagged model, which allowed us to assess directionality among study variables. In other words, we provide evidence for some level of temporal precedence by confirming whether scores on one variable predicted (residualized) change scores in another variable (while controlling for baseline scores on that outcome variable). Importantly, this approach allowed us to simultaneously assess variables as predictors and outcomes of each other. Nevertheless, in the absence of an experimental design, our findings cannot address the causality of the significant associations reported in this study. In other words, we cannot conclude that BPN fulfillment (or lack thereof) *causes* changes in sleep, nor can we conclude that higher daytime dysfunction *causes* reduced perceived fulfillment of BPN. Furthermore, we note the bias in the pattern of missing data on extraversion as a critical limitation of the present study. Findings should, therefore, be interpreted with this important limitation in mind. Future research is necessary to validate the findings of this study in a larger sample, where the pattern of missingness does not pose any bias in the interpretation of results.

Second, assessments of both sleep and BPN were based on self-report surveys. Self-report measures are invaluable for understanding psychological phenomena from a subjective perspective but are subject to the typical flaws of recall data. Consequently, objective measures of sleep variables (eg, actigraphy, polysomnography) may be worthwhile for future studies to validate findings of the present study.

Third, our sample size was relatively small, particularly for the number of key variables and covariates we examined. Future research, therefore, should examine these associations with larger samples. Larger samples would allow for the assessments of possible moderators (eg, gender, athlete status) of the associations between BPN and sleep. Furthermore, the findings were based on a homogenous sample of university students from a small, northeastern liberal arts university and thus may not be generalizable to other university populations. The university at which data were collected for the present study has an open curriculum, where students are encouraged to select from diverse course offerings. This level of freedom and flexibility would likely influence the autonomy subscale of the BPN measure. Thus, future research should examine these associations within the context of larger universities with more rigid course expectations.

Fourth, although we included mental illness diagnosis as a covariate, this measure was limited in that the item specified the diagnosis of a mental illness by a physician. However, such a diagnosis could be made by other health professionals. Future studies should specifically assess these associations among clinical samples to confirm the consistency of these findings. Additionally, it would be particularly worthwhile to determine whether interventions that facilitate the fulfillment of BPN are effective in improving sleep among those who have clinical levels of sleep problems.

Fifth, although we examined directionality between sleep and the perceived fulfillment of BPN across 2 semesters, the first assessment was taken during the second semester of the school year, whereas the second assessment was taken during the subsequent fall semester.

Given that students were on summer break between the 2 assessments, it is unclear how students' summer routines (or lack of routines) may have influenced our findings. For example, perhaps the summer provided opportunities for participants to "reset" both their sleep-wake schedules and their perceived BPN satisfaction. It is critical for future studies to extend these findings and examine longer-term associations between the fulfillment of BPN and sleep across multiple semesters, as well as during scheduled breaks from school. Another important direction for future research would be to consider using a person-centered approach to determine whether there are specific subgroups of individuals based on various sleep variables (eg, there may be a subgroup of students who report relatively lower sleep duration during both the week and the weekend, and a different subgroup of students who report relatively shorter week sleep duration but longer weekend sleep duration as a way to "catch up" on lost sleep during the week). These subgroups could subsequently be compared on various components of daytime function and perceived fulfillment of BPN.

Sixth, our measure of daytime dysfunction was a composite of perceived sleepiness and enthusiasm, as has been operationalized in the PSQI.[3] This assessment, however, represents a limited scope of the possible aspects of one's daytime functioning. Perhaps, a distinction should be made among multiple dimensions of daytime dysfunction, including but not limited to cognitive, physiological, physical, and emotional vitality, to better understand how BPN relate to how individuals assess their ability to carry out a wide range of tasks and responsibilities throughout the day.

Lastly, given that our measure of BPN was adapted from the Basic Psychological Needs–Work Domain questionnaire, as has been done in other studies,[77,78] additional studies are needed to provide further validation of the use of this adapted scale within academic settings.

Conclusions

The perceived fulfillment of BPN predicted improvements in week sleep duration and perceived sleep quality 1 semester later; furthermore, there was a significant bidirectional association between perceived fulfillment of BPN and daytime dysfunction. Findings provide further empirical support for BPN theory by demonstrating the importance of fulfilling BPN for a critical human behavior: sleep. Future research is needed to validate whether sleep may be a key mechanism that explains the link between BPN and various indices of well-being. The dynamic association between daytime dysfunction and BPN highlights the role of vitality for well-being. Furthermore, results have implications for interventions that aim to improve sleep among university populations. Although many sleep interventions tend to focus on sleep hygiene and environmental aspects of sleep, our findings highlight the importance of attending to BPN for subsequent improvements in both sleep duration and quality. One approach could be to provide opportunities that nurture university students' BPN so that they can be well, in order to sleep well.

Conflict of interest

The authors report no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleh.2019.02.007.

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